
# Smart farming in pig production and greenhouse horticulture

An inventory in the Netherlands - extract chapter Smart pig production

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# Smart pig production

## Farm level smart solutions

### Introduction

In terms of piglets weaned per sow and year, the Netherlands is the second country worldwide (29.5; Hoste, 2017b), only surpassed by Denmark. Cost of production amounts to about € 1.69 per kg of hot carcass weight, far lower than the € 2.63 per kg in South Korea (Hoste, 2016), typically reflecting the difference in production efficiency between both countries. The number of farms with pigs in the Netherlands is halved every 10 years, as a result of the strong competition. Availability of workers is limited and expensive (€ 25 per hour), resulting in pressure to improve labour performance and automation. Strong competition has led to high performance, low cost of production and shake-out of less-performing farms. Smart solutions have supported these developments.

The pig supply chain in the Netherlands is not vertically integrated but can be defined as a loosely coupled system, typically without written agreement, but based on common trade habits (Janssens et al., 2012). Product information is shared throughout the supply chain only to a limited extent: slaughter quality information is provided back to the farmer, but farm of origin information is kept with the product only to some extent. Still, in terms of food safety and product traceability, the supply chain is well organised, but data sharing throughout the supply chain would deliver improved opportunities to inform consumer about the origin and way of production of their meat. Pilot projects are being performed to improve information sharing up to the consumers. Part of the consumers are especially interested in products of their own region, or in products of animals that they have seen themselves. To this end, individual identification of animals and keeping this information is necessary and could support the trust of consumers in their products. Min (2016) describes a development of agriculture towards what he mentions ‘eatertainment’, in which consumers enjoy a combination of food and entertainment (like art, music etc.), as an opportunity for creating added value.

### Smart solutions already applied in practice

*Management information system*

A high efficiency requires a high level of management capabilities. Dutch pig farmers all make use of a Management Information System (MIS), a software tool for recording all pig-related events, like giving birth or mortality. This tool supports the management of production processes, by drawing the farm workers’ attention to necessary activities and interventions. Farmers also benchmark their data, not only over time (self-mirroring) but also with their colleagues, as to be able to mutually learn and improve results. Farmers typically are member of study groups of farmers, exchanging experiences and results in quite some detail and based on trust. Application of a MIS is a prerequisite for high performance in pig production. Farmers can use a hand-held device, reading the animal number (electronic identification is necessary), and showing performance information of the individual animals (Figure 1). This supports decision-making and instant interventions. Electronic identification (EID) of animals is necessary, which is done on a limited number of farms. Further development of EID is expected. A hand-held device also supports instant data entry, improving the data quality.

***Figure 1*** *Hand-held reader and electronic ear tag. Photo courtesy of MS Schippers*

A MIS typically produces performance information of individual animals, groups of animals, or on farm level. A current development is to implement user-friendly graphical reporting of results, including a dashboard-like presentation (Figure 2). This way of presentation gives quick insight into relevant parameters and draws attention to necessary interventions, rather than drowning the user in lots of data. This way an MIS is developing towards a decision-support system. Management information systems are increasingly linked to other modules, including financial administration.

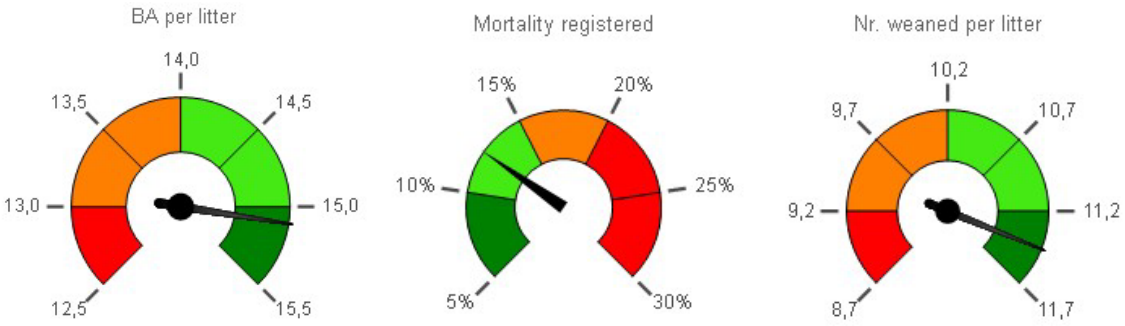


***Figure 2*** *Example of graphic dashboard presentation in a Management Information System for pig farms. Courtesy of Agrisyst*

*(Electronic) individual identification of pigs*

Sows are typically identified and managed individually. However, just part of the sows in the Netherlands have an electronic ear tag, mainly depending on the feeding equipment: for individual recognition at an automatic feeder station, sows need EID. EID is based on the Radio Frequency Identification technique (RFID). Measuring individually gives the opportunity for individual observation of growth, feed intake, and birth weight, behavioural patterns to signal diseases or activities to be performed (like insemination or separation), which is very supportive for operational management. Also if sows do not report to a feeding system this gives a signal of lack of appetite and maybe a disease.

Fattening pigs are typically being identified as a group (pen number, farm number), rather than as individuals. Electronic individual identification would give different advantages, but is assumed to be not economically feasible yet. This information supports improved operational management and labour saving in large groups, as well as in other stages of the supply chain, such as improved breeding (see Section 3.2) and improved traceability (see Section 3.3). Only a limited number of farmers are pioneering now with EID for fattening pigs.

*Advantages of EID for fattening pigs*
With EID, fattening pigs can be weighed individually, and actual feed intake can be measured individually. This gives the opportunity for continuous adaptation of the individual feeding regimes, both in terms of quantity and feed type. Such individual measuring of individual growth and feed intake is an important input for monitoring of the farm performance and gives an opportunity for immediate response in the case that individual pigs would not eat or grow. Individual performance data improve the forecast when animals are ready-to-market. Individual measuring gives the ability to benchmark within the farm: differences in results between pens or departments can be measured, which could be related to e.g. different climate circumstances. This measuring-analysis-control cycle leads to improved operational management and to reduced variability among pigs (precision livestock farming). In practice sometimes a simpler solution is already in use in which one pen has a weighing floor and weight development in the pen is assumed to represent the entire departments' performance.

*Automatic sorting possible next step*
On a few farms in the Netherlands fattening pigs are kept in large groups (like 300 pigs per pen). Pigs are being weighed either by a scale or by a vision system, in order to decide in which department the pig can get feed (feed composition differs according to their actual need) as well as to sort out pigs. In case of big groups of fattening pigs, sorting out can be not only difficult (for instance finding individuals in a big group and taking them out), but also dangerous (if a farmer faints, pigs might start attacking and even eating an unconscious person – although the probability that such an event might happen is very small, it prohibits some farmers from implementing such big groups). Automatic sorting out of sick animals (as long as they are able to walk and come to a monitor and passage way) and pigs ready for transport to the slaughterhouse can save labour as well as observation errors. Several commercial solutions are available, like Nedap Pig Sorting, Aco Funki Pig Sorting, or Optisort.

*EID expected to be common use in 10 years*
Electronic animal registration is found on a quarter of all pig farms in the Netherlands (Burgers, 2015a). Burgers does not make a distinction between sow and fattening pig farms, but most likely these are mainly large sow farms; in fattening, EID is only applied at a few farms. EID is likely to increase to common use within the next 10 years, as the price is decreasing and farmers are increasingly aware of advantages. Currently, RFID tags are not allowed as legal Identification & Registration means in the Netherlands, but this might change, as electronic identification has become a legal prerequisite for certain kinds of easier inspection of pigs for export.

*Cough monitor as early warning system*
A cough monitor, developed by the company Fancom, functions as early warning system to recognise potential (specific) diseases, by measuring coughing noises and comparing them to a pig farming noises' database. Microphones in the stable measure the sounds. This application is only used on a limited number of farms. A similar system has recently been developed by the pharmacy company Boehringer Ingelheim, with their Cough Index Calculator, which is an app on the smart phone.

**Heat detection for easier insemination management**
Non-pregnant sows can be housed in a way that they can see and smell boars. In combination with a reader and EID, sows with a peaking visiting frequency of the boar are likely to be or soon become in heat (Nedap). Other systems are being developed to have the boars walking in front of sows in heat, making it easier to inseminate, like the DateGate (Vereijken-Hooijer), or the Aco Funki system. In dynamic groups heat detection is applied on about 90% of the farms.

*Pregnancy testing common on Dutch sow farms*
Sow farmers use ultrasound testing devices to check for the pregnancy of sows. This is typically done 21 days after insemination. Sows proving to be non-pregnant are moved to the insemination department, in order to get her pregnant and thus reduce economic losses by non-productive sows. Pregnancy testing is common on Dutch sow farms.

*Automatic feeding systems at 75% of the Dutch farms*
Based on time-related feed supply patterns per pen, feed is automatically transported and released at a few specific times per day. Other systems make use of sensors in troughs to signal the need for refilling. Automatic feeding systems are found on three out of four pig farms in the Netherlands (Burgers, 2015a). Typically such systems are remote controlled.

*Automatic balance farrowing pens to prevent crushing piglets*
A balance floor in a farrowing pen is a moveable floor for either the sow or the piglets, in order to prevent crushing of the piglets when the sow is going to lay down (Figure 3). The floor is automatically lifted or left down if the sow (no longer) touches a sensor when she is going to stand or lay down.

***Figure 3*** *Balance floor in a farrowing pen. Photo Courtesy of Nooyen flooring*

*New generation cleaning robots with monitoring needed*
A cleaning robot is an automatic high-pressure device moving around in pig houses to clean and disinfect departments (Figure 4). As a robot, it follows an exact pattern in order to clean and disinfect. However, cleaning results are not monitored by the system, and farmers sometimes have to

do additional work to get it really clean. A future improvement could be to make the robot smarter by having it measure its work and then adapt the routine if necessary. Only then it saves tedious work at a reasonable cost.


***Figure 4*** *Cleaning robot. Photo courtesy of MS Schippers*

*Climate control improves animals' living circumstances and performance*
Pigs in the Netherlands are usually kept indoors. To control the indoor climate, climate control systems have been developed. The simplest climate control consists of a temperature-based air flow control. More advanced climate control systems also measure $CO_2$, $NH_3$, and relative humidity. Climate control is combined with specific information about the animals in the department, as the own heat production of animals depends on parameters like age, pregnancy and growth. The most advanced climate control systems measure outdoor weather conditions, such as temperature and rainfall, to consider the conditions for the optimal inside climate (for example, during a heavy shower the air inlet is reduced instantly to prevent a quick inside temperature decrease). Also, a day-night rhythm can be taken into account. Typically during hot days pigs grow less as they have less appetite. By continuous multifactorial monitoring and climate adaptation, the living circumstances for the animals improve, which in turn increases the animals' performance. The climate can be controlled by not only changing the ventilation volume, but also by adapting the position of inlet valves, the choice of air inlet (via e.g. soil pipes with reduced temperature fluctuations, and/or direct inlet), heating, or cool-spraying. Climate control is applied on virtually all farms, although they differ in the complexity of the control. Climate control devices are remote controlled.

Information of climate control devices is increasingly presented in a smart way. Rather than showing individual parameters' results, the outcome on whether the ambient climate in the departments would require attention by the farmer is shown (based on the so-called management by exception approach). Increasingly, visual presentation of outcomes is applied (Figure 5).


***Figure 5*** *Climate control devices. Photo courtesy of Fancom*

## Smart solutions in development

Interviewees were asked about new developments there are involved in. Three directions of development are defined: data collection, analysis and use of data.

Improved *data collection* includes collecting more parameters, monitoring continuously, and collecting data of individual pigs rather than group averages. Data collection also refers to the way it is done: automatic data collection is expected to increase (including vision techniques) as it improves data quality (fewer entry mistakes, fully objective), real-time availability, and is not vulnerable to the farmers' mood to record.

*Data analysis* includes real time analysis and application in management decisions, better use of data in deriving relationship by linking data (big data).

As more information is available a *smart way to present* should be developed. An increasingly visually orientation can be made possible by proper visualisation, which makes data more valuable and the use is more user-friendly and attractive.

*Biometric identification to avoid use of tags*
An alternative to (electronic) ear tags for individual identification is a biometric identification for pigs based on imaging techniques (Iris scanning, and Retinal vascular imaging), to avoid the use of tags. Currently biometric identification is being developed based on vision system, recognising the shape and size of animals.

*Monitoring the behaviour of animals*
Behaviour of animals can be monitored by video. We are not aware of automatic video-based monitoring systems to warn for or predict aggressive behaviour. Given the increased attention to animal welfare, and especially the intact males' behaviour, this would be an interesting development.

*Biosensors to trace fever or ovulation*
Biosensors at not being used yet in commercial pig production. However, several applications are conceivable, like temperature and hormone measurements in order to trace fever or ovulations.

**Beacons for biosecurity and labour control**

A beacon is a small Bluetooth low energy radio transmitter and can be used as an indoor positioning system for farm staff inside the stables (Figure 6). Farm workers wear a beacon and signals are being received by standard smartphones placed at specific places in every barn (like at the entrance). This way the staff's movement can be measured continuously. Objective control of farm staff movements can support to control biosecurity, as is currently being tested in Segovia, Spain (Piñeiro, 2017). In a conventional system biosecurity (hygiene) is managed by protocols regarding the control of external pathogens entering the farm and the spread of the pathogens within the farm, as it requires strict rules regarding presence and working patterns for the staff (e.g. from young to older pigs, in order to reduce infection risks). In addition to biosecurity control, it can support time management of farm workers.

As far as known this technique is not yet implemented on pig farms in the Netherlands, but is being tested on two farms. The technology could be used to forecast working patterns of farm workers, to lock specific places in the stable that do not fit in the allowed working pattern, or to give a warning for unallowed or too long presence on specific locations.

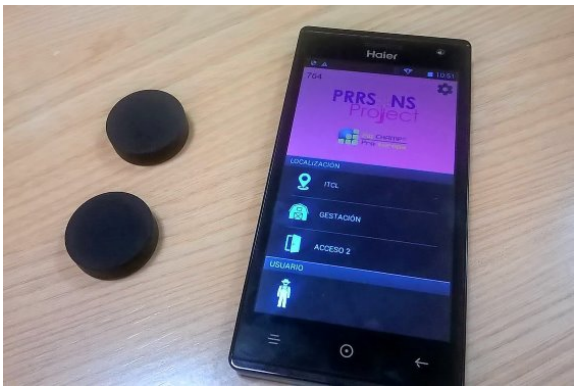


***Figure 6*** *Beacons for farm staff. Photo courtesy of Carlos Piñeiro*

# Smart solutions in other stages of the pig supply chain

*Pig breeding*

Breeding organisations are improving their speed of genetics progress by new technologies like genomic selection, CT scans, and use of video and 3D camera images. Combining large amounts of data leads to far more insight in the animals' genetic potential and results in progress than in history. Breeding organisations typically improve animal performance (e.g. weaned piglets per sow and year, daily gain, feed efficiency), animal welfare and meat quality.

*Feed production*

Feed production is partly being automated, including sampling of incoming ingredients, grinding, mixing, and pelletising of the feed.

*Slaughtering*

*Carcass classification*

Slaughter pigs are being graded at the slaughter line in order to pay the providing farmer according to the delivered weight and quality, related to marketing opportunities per (main) part of slaughter pigs, as well as to make a preselection of market destinations. To this end different techniques are being developed and in use, like the so-called FOM (based on difference in reflectance of meat and fat), AutoFOM (based on ultrasounds) and 3D video classification system, in order to measure lean meat

percentage, carcass composition and weight of individual primal parts of the carcass (like hams). Especially the AutoFOM system is popular as it gives more detailed information on the carcass composition than the FOM system.

*Slaughter line automation*
Slaughter lines are partially automated and robotised in order to save labour input, like automated driveway systems, electric or $CO_2$ stunning systems, carcass washing, scalding and dehairing, different saw systems to open the carcass and to cut specific bones like the backbone, etc. Some of those systems continuously monitor the size of the pigs/carcasses and adjusting their precise movements. Carcasses can be divided automatically based on a vision system that is makes a 3D carcass profile (Figure 7). This comprises automatic (robotised) cutting of the carcass to have the best yielding cuts (Vision-systems.com). Also automatic transport and storage identification is performed, based on hook identification and linked to the animals' ear number. (www.mps-group.nl)

***Figure 7*** *Laser-driven cutting positioning for dividing carcasses. Photo courtesy of Marel Red Meat Slaughtering*

**Smart packaging**
Retailers issue customer cards with specific offers and price deductions. Data on shopping behaviour is being used both to analyse shopping profile categories (in order to improve the retail concept), and to be able to offer specific products.

RFID tags are being used in shops both as an anti-theft system and for identification and automatic payment. Increasingly supermarkets are switching towards self-scanning and self-checkout by customers.

A new development and, as far as known, not used yet in the Netherlands, is a time and temperature indicator for fresh food products, developed by Keep-it Technologies. This smart shelf life indicator is put on food products by a small self-adhesive label. Based on time and temperature a reaction of non-toxic chemicals in the little device results in a changing colour of the indicator, which in the end shows the remaining shelf life of the product. This smart indicator replaces static indications like 'best before', and contributes to a reduction of food losses.

*Checking nutritional content of food*
Wageningen University & Research developed a device and app to check the nutritional content of food products. It can be used to see if the content is in accordance with the information on the label, like animal type (beef vs. horse meat) or fat content. It can enhance consumer trust.

# Smart supply chain

*Information exchange throughout supply chain*

Abattoirs have information systems installed to inform farmers about the performed quality of supplied pigs on an individual basis (slaughter weight and some parameters on realised qualities), like Vion FarmingNet. The application has the ability to analyse seasonal patterns, differences between departments in the barn, or between e.g. origin or hybrid of the pigs. Farmers can use this software to inform the slaughterhouse about the number of pigs they plan to send for slaughter on a specific day, but also some specific quality parameters can be provided (e.g. either or not intact boars, market program etc.).

EDI Circle is a system in which invoices are being shared and digitally. Main users are feed suppliers, dairy and meat processors, accountants and farmers. Since invoices are digitalised, information can easily be processed in accounting software.

Individual identification tags are being used for pigs in the Netherlands, both electronic and non-electronic. Advantages of EID surpass the farm level, as this allows for easier traceability of the animals throughout the supply chain. Currently all pigs do receive an ear tag after birth (either electronic or non-electronic) with the farm ID number and a serial number, which is a legal obligation for identification and registration, for the purpose of managing contagious disease outbreaks. Piglets are typically being transported to another farm for the fattening stage. Once pigs are ready to be sent to a slaughterhouse, they receive an obligatory additional ear tag, on which the final farm's ID number must be represented. Application of an electronic identification might save this additional step. Also in terms of animal welfare the animal's integrity is improved when less tags are necessary. Once farmers have identified their pigs individually and electronically, guarantees can be given that certain pigs are being produced on farms that fulfil the requirements of certain market programs (like Varken van Morgen, Good Farming Star, Keten Duurzaam Varkensvlees etc.). Also per farm differentiations can be made between pigs that, for example, did or did not receive any antibiotics during their life, in order to guarantee the abattoir to only deliver pigs without antibiotics. Once pigs are individually identified throughout their life, this information can be used for optimising breeding programmes, as not only on-farm information is being used, but also slaughter performance information can be used in the breeding programme.

The Dutch government is willing to improve the transparency of the production process 'from farm to fork', aiming to improve trust of the consumers. When pigs are identified individually and information is kept until the ready meat product, places of origin can be communicated towards consumers, like farm numbers where the pigs were born and raised and the numbers of plants where they were slaughtered and processed. Therefore, the current supply chain quality system IKB should be improved to implement this information flow. Farmers' organisation POV is developing a generic Supply chain quality system, based on data sharing throughout the supply chain, and meant for general application. Details are not known yet.

*Logistic optimisation*

A lot of transport takes place for feed and animals. Companies have developed software to minimise transport distances, like Vion for getting pigs from lots of farmers to different slaughter plants, or Rendac to arrange transport of fallen stock. But also feed companies are using such logistics optimisation software to reduce feed transport.

*Retailer apps*

Some retailers in the Netherlands are launching apps that give information on the origin of products, including pig meat. The 'Boer @p' was launched at retailer Agrimarkt in the city of Goes, linking consumers with individual producers and farmers and their products in the shop. Using the TTAG technology, individual product items can be identified accurately worldwide, by automatic identification, recording and linking information of products throughout the agro and food supply chains. Consumers can find information with their smart phone on origin, way of production and quality of products (Connectingagriandfood.nl). Very recently major retailer Albert Heijn launched its Augmented Reality Product scanner (AH.nl). This app gives information on ingredients, origin and recipes.

# Continuous developments in smart farming

## Some smart pig farm related projects

A few current projects are being presented here as a selection to show that developments in smart pig farming are being supported.

*FarmHack*
FarmHack (http://www.farmhack.nl/agrivision-hack-smart-sharing-data/) is an initiative of some enthusiastic individuals to improve innovation in the pig sector by setting up a hackathon. The hackathon is a kind of marathon for developing smart ideas. In 2017 five groups of eager volunteers elaborated their ideas:

- SwineSmarts; hassle-free data flows controlled by the farmer. SwineSmarts closes feedback loops by linking slaughter data back to the farmer and to his suppliers of feed and genetics, thus bringing value to each.
- Piglantir, health monitor and predictor for pig rearing without antibiotics. Based on biometric identification (no tag, tattoo or chip), combining data from open and partner provided data sources to uncover relationships between environment, climate, nutrition, robustness and health status.
- PigAlert, eyes and ears in the barn. Series of visual images of individual pigs and the group inform a self-learning system about animal behaviour. After time, the system recognises anomalies. Sound recording and feed intake are fed into the system as well, to improve the analyses.
- FedBest, personalised diet for robust sows. Based on data on genetics, feed composition, feed intake patterns, optimal feed diet is determined.
- Porklane, DIY sales chain. An online marketplace was prototyped for the activities performed in the supply chain, where stakeholders in the supply chain can meet and join forces.

*Internet of Food and Farm 2020*
The Internet of Food and Farm 2020 (https://www.iof2020.eu/) is an EU-funded international project that creates an innovation ecosystem that accelerates the uptake of novel technologies in the farming and food sectors. In the framework partners can set up use cases. Two use cases are being set up so far in the pig production sector, one on pig farm management and the other on Meat transparency and traceability.

*Pig farm management*
This use-case focuses on linking data across the value chain in order to provide the pig farmers with the necessary information to effectively implement and carry out their management activities. It provides the five involved farmers with management information that enables continuous improvement of its sustainable production. Early warning systems are being developed on several group-level daily data streams, and boar taint presence is being reported to farmers. Expected results include a reduced boar taint in meat, increased feed efficiency and daily gain, improved animal welfare and a lowered carbon footprint.

*Meat Transparency and traceability*
This use-case aims to increase transparency in the meat value chain. A data system collects and shares data that is not yet covered by existing traceability data systems with supply chain partners. The majority of the data will be collected in the use-case on Pig Farm Management. Information will be shared among supply-chain partners to optimise business processes and reduce negative environmental aspects; quality issues will be identified, such as interruption of the cold chain; and transparency between producers and consumers will be increased. Expected results include an increased consumer trust in meat production, improved communication on the animals' welfare and health; optimised business processes; verification of pork quality; increased margins for high-quality products, and improved environmental performance (e.g. energy consumption, waste creation).

## Some pig production related apps

Several apps are available for pig farmers (only in Dutch) (Sources: Burgers (2015b), AgroApps.nl):

- Apps with practical information on pig farming, like De Varkens App (commercial app as pocket book with practical information on pig farming); Hitte stress app (informing about ambient temperature and advice on activities for improved climate control in the barn); Abnormaal gedrag app (showing abnormal behaviour with augmented reality in 3D of animals like pigs); IJzercalculator (advising on actual iron need of a piglet).
- Commercial ordering apps, like from several feed companies, or MS Schippers equipment supplier.
- Farm management apps like BigFarmNet (commercial app of an equipment supplier, gives an overview of production and climate information; it is linked with the management information system, as well as with the climate control system).
- De Heus benchmarking app, in order to compare farm parameters with national averages and top 25% farms.
- Identification app Dieren en bedrijven of the Ministry of Economic Affairs, to check numbers of animals and farms in the national identification and registration system.
- Apps with market information, like Agrarische bedrijven: Boerderij Business (commercial app with market information of commodities).
- The Cough Index Calculator is an app of pharmacy company Boehringer Ingelheim, measuring coughing behaviour and suggesting to contact a veterinarian.

To explore the potential of nature to improve the quality of life

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